In [1]:

```
# ANOVA Monofactorial

# 1. Carga inicial de datos:

if(!require(psych)){install.packages("psych")}
if(!require(FSA)){install.packages("FSA")}
if(!require(Rmisc)){install.packages("Rmisc")}
if(!require(ggplot2)){install.packages("ggplot2")}
if(!require(car)){install.packages("car")}
if(!require(multcompView)){install.packages("multcompView")}
if(!require(multcompView)){install.packages("multcomp")}
if(!require(lsmeans)){install.packages("lsmeans")}
if(!require(rcompanion)){install.packages("rcompanion")}


Datos <- ("
Algoritmo       Ejecucion  Tiempo
'Algoritmo A'      '1'    12060
'Algoritmo A'      '2'    14089
'Algoritmo A'      '3'    13502
'Algoritmo A'      '4'     9574
'Algoritmo A'      '5'    14056
'Algoritmo A'      '6'    11569
'Algoritmo A'      '7'    13047
'Algoritmo A'      '8'    13275
'Algoritmo A'      '9'    14257
'Algoritmo A'      '10'   15075
'Algoritmo A'      '11'   12506
'Algoritmo A'      '12'   11557
'Algoritmo A'      '13'    9548
'Algoritmo A'      '14'   11514
'Algoritmo A'      '15'   16015
'Algoritmo A'      '16'   13004
'Algoritmo A'      '17'   10510
'Algoritmo A'      '18'   13040
'Algoritmo A'      '19'   17098
'Algoritmo A'      '20'   13080
'Algoritmo B'      '1'    11080
'Algoritmo B'      '2'    12089
'Algoritmo B'      '3'    12538
'Algoritmo B'      '4'    10571
'Algoritmo B'      '5'    12010
'Algoritmo B'      '6'    12598
'Algoritmo B'      '7'    13543
'Algoritmo B'      '8'    13547
'Algoritmo B'      '9'    13217
'Algoritmo B'      '10'   15297
'Algoritmo B'      '11'   12210
'Algoritmo B'      '12'   11299
'Algoritmo B'      '13'   10067
'Algoritmo B'      '14'   11279
'Algoritmo B'      '15'   14006
'Algoritmo B'      '16'   12099
'Algoritmo B'      '17'   11581
'Algoritmo B'      '18'   14012
'Algoritmo B'      '19'   15069
'Algoritmo B'      '20'   12000
'Algoritmo C'      '1'     9081
'Algoritmo C'      '2'    11012
'Algoritmo C'      '3'    11529
'Algoritmo C'      '4'     9569
'Algoritmo C'      '5'    11092
'Algoritmo C'      '6'    11524
'Algoritmo C'      '7'    12522
'Algoritmo C'      '8'    12588
'Algoritmo C'      '9'    12241
'Algoritmo C'      '10'   13257
'Algoritmo C'      '11'   11294
'Algoritmo C'      '12'   10226
'Algoritmo C'      '13'    9591
'Algoritmo C'      '14'    9224
'Algoritmo C'      '15'   12033
'Algoritmo C'      '16'   11063
'Algoritmo C'      '17'    9537
'Algoritmo C'      '18'   13014
```

```
'Algoritmo C'      '19'   14033
'Algoritmo C'      '20'   11093
")

# Lectura de los datos
Data <- read.table(textConnection(Datos), header=TRUE)
# Ordenar los datos segun los ingresamos
Data$Algoritmo <- factor(Data$Algoritmo, levels = unique(Data$Algoritmo))

# 2. Lectura de datos / Verificación de lectura

library(psych)
headTail(Data)
str(Data)
summary(Data)
rm(Datos)

# 3. Resumen organizado

Summarize(Tiempo ~ Algoritmo, data = Data, digits = 4)

# 4. Diagrama de cajas

M <- tapply(Data$Tiempo, INDEX = Data$Algoritmo, FUN = mean)
boxplot(Tiempo ~ Algoritmo, data = Data)
points(M, col = "red", pch = "+", cex = 2)

# 5. Información de promedios e intervalos de confianza

Sum <- groupwiseMean(Tiempo ~ Algoritmo, data = Data, conf = 0.95, digits = 3, traditional = FALSE, percenti
Sum


# 6. Gráficos de promedios e intervalos de confianza

library(ggplot2)
ggplot(Sum,
       aes(x = Algoritmo, y = Mean)) +
       geom_errorbar(aes(ymin = Percentile.lower,
                         ymax = Percentile.upper),
                         width = 0.05, size = 0.5) +
                    geom_point(shape = 15,
                               size = 4) +
                    theme_bw() +
                    theme(axis.title = element_text(face = "bold")) +
                    ylab("Tiempo promedio, s")

# 7. Modelo Lineal

model <- lm(Tiempo ~ Algoritmo, data = Data)
summary(model)

# EMPIEZA EL CAMBIO

# 8. Histograma de residuos

X <- residuals(model)
library(rcompanion)
plotNormalHistogram(X)

# 9. Dispersión de residuos

plot(fitted(model),residuals(model))

# 10. Gráficos del modelo lineal

plot(model)

# 11. ANOVA

library(car)
Anova(model, type = "II")


# ------
```

```r
# Ajuste de promedios | Mínimos cuadrados | Post-Hoc

# 1. Separación de promedios

library(multcompView)
library(lsmeans)
marginal <- lsmeans(model, ~ Algoritmo)
pairs(marginal, adjust="tukey")

# 2. Visión compacta

library(multcomp)
CLD <- cld(marginal, alpha=0.05, Letters = letters, adjust = "tukey")
CLD

# 3. Gráfico promedios, intervalos de confianza y letras de separación

# Ordenamos los niveles para imprimirlos
CLD$Algoritmo <- factor(CLD$Algoritmo, levels = c("Algoritmo A", "Algoritmo B", "Algoritmo C"))
# Removemos espacios en blanco
CLD$.group <- gsub(" ", "", CLD$.group)

library(ggplot2)
ggplot(CLD,
       aes( x = Algoritmo,
            y = lsmean,
            label = .group)) +
       geom_point(shape = 15, size = 4) +
       geom_errorbar(aes(ymin = lower.CL,
                         ymax = upper.CL),
                         width = 0.2,
                         size = 0.7) +
       theme_bw() +
       theme(axis.title = element_text(face = "bold"),
             axis.text = element_text(face = "bold"),
             plot.caption = element_text(hjust = 0)) +

       ylab("Promedio del minimo cuadrado \n
             Tiempo de ejecucion") +

       geom_text(nudge_x = c(0,0,0),
                 nudge_y = c(1100, 1100, 1100),
                 color = "black")
```

```
Loading required package: psych

Loading required package: FSA

## FSA v0.9.4. See citation('FSA') if used in publication.
## Run fishR() for related website and fishR('IFAR') for related book.


Attaching package: 'FSA'


The following object is masked from 'package:psych':

    headtail


Loading required package: Rmisc

Loading required package: lattice

Loading required package: plyr


Attaching package: 'plyr'


The following object is masked from 'package:FSA':

    mapvalues


Loading required package: ggplot2


Attaching package: 'ggplot2'


The following objects are masked from 'package:psych':

    %+%, alpha


Loading required package: car

Loading required package: carData

Registered S3 methods overwritten by 'car':
  method       from
  hist.boot    FSA
  confint.boot FSA


Attaching package: 'car'


The following object is masked from 'package:FSA':

    bootCase


The following object is masked from 'package:psych':

    logit


Loading required package: multcompView

Loading required package: lsmeans

Loading required package: emmeans

The 'lsmeans' package is now basically a front end for 'emmeans'.
Users are encouraged to switch the rest of the way.
See help('transition') for more information, including how to
convert old 'lsmeans' objects and scripts to work with 'emmeans'.
```

```
Loading required package: rcompanion


Attaching package: 'rcompanion'


The following object is masked from 'package:psych':

    phi
```

A data.frame: 9 × 3

	Algoritmo	Ejecucion	Tiempo
	<fct>	<chr>	<chr>
1	Algoritmo A	1	12060
2	Algoritmo A	2	14089
3	Algoritmo A	3	13502
4	Algoritmo A	4	9574
...	NA	...	...
57	Algoritmo C	17	9537
58	Algoritmo C	18	13014
59	Algoritmo C	19	14033
60	Algoritmo C	20	11093

```
'data.frame':   60 obs. of  3 variables:
 $ Algoritmo: Factor w/ 3 levels "Algoritmo A",..: 1 1 1 1 1 1 1 1 1 1 ...
 $ Ejecucion: int  1 2 3 4 5 6 7 8 9 10 ...
 $ Tiempo   : int  12060 14089 13502 9574 14056 11569 13047 13275 14257 15075 ...
      Algoritmo    Ejecucion         Tiempo
 Algoritmo A:20   Min.   : 1.00   Min.   : 9081
 Algoritmo B:20   1st Qu.: 5.75   1st Qu.:11093
 Algoritmo C:20   Median :10.50   Median :12094
                  Mean   :10.50   Mean   :12234
                  3rd Qu.:15.25   3rd Qu.:13262
                  Max.   :20.00   Max.   :17098
```

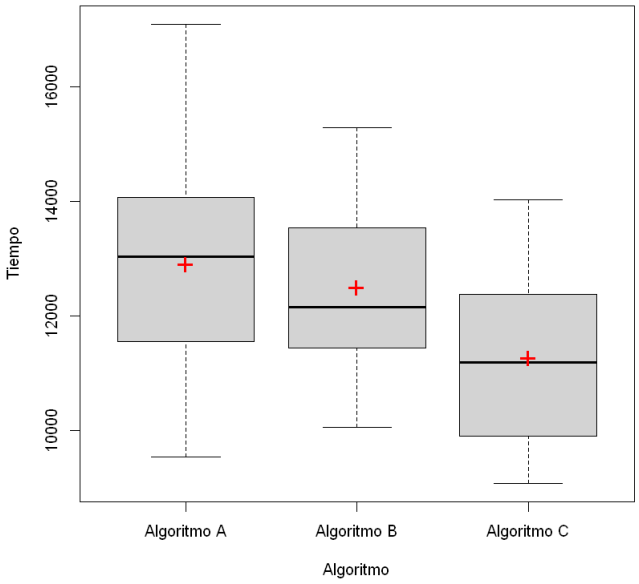
A data.frame: 3 × 9

Algoritmo	n	mean	sd	min	Q1	median	Q3	max
<fct>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
Algoritmo A	20	12918.80	1941.191	9548	11566.00	13043.5	14064.25	17098
Algoritmo B	20	12505.60	1414.667	10067	11510.50	12154.5	13544.00	15297
Algoritmo C	20	11276.15	1424.242	9081	10067.25	11193.5	12311.25	14033

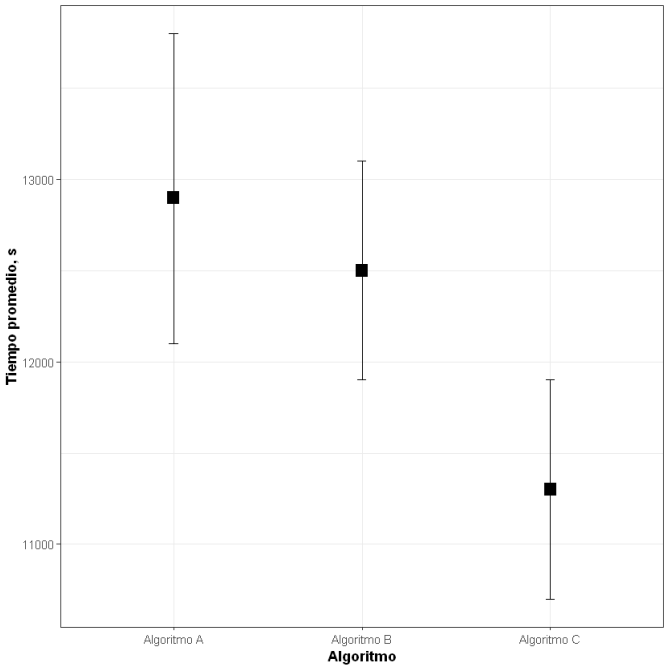
A data.frame: 3 × 6

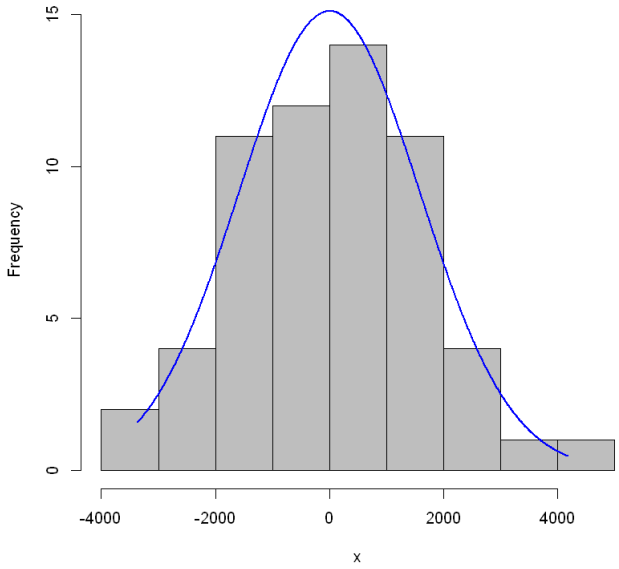
Algoritmo	n	Mean	Conf.level	Percentile.lower	Percentile.upper
<fct>	<int>	<dbl>	<dbl>	<dbl>	<dbl>
Algoritmo A	20	12900	0.95	12100	13800
Algoritmo B	20	12500	0.95	11900	13100
Algoritmo C	20	11300	0.95	10700	11900

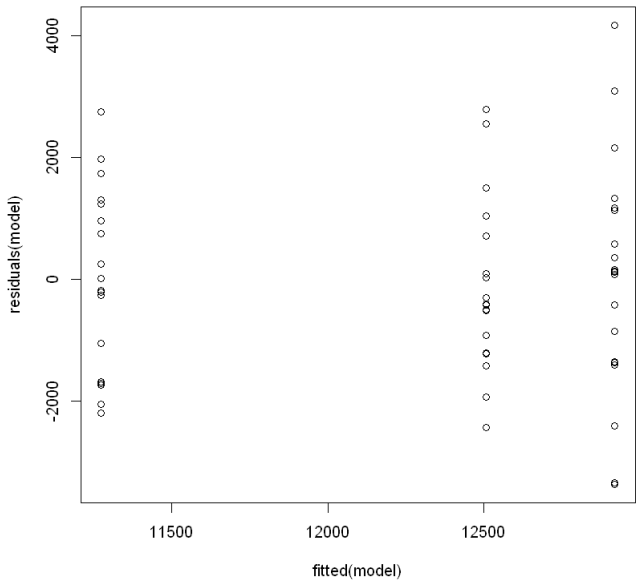
```
Warning message:
"Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
i Please use `linewidth` instead."
```

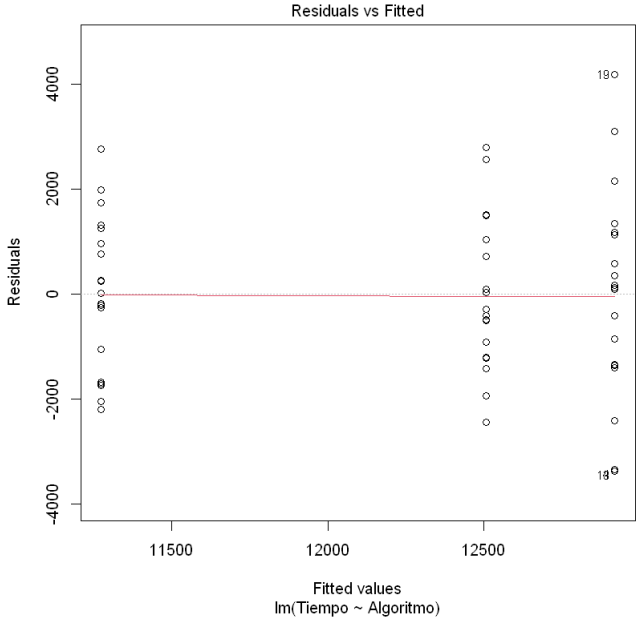


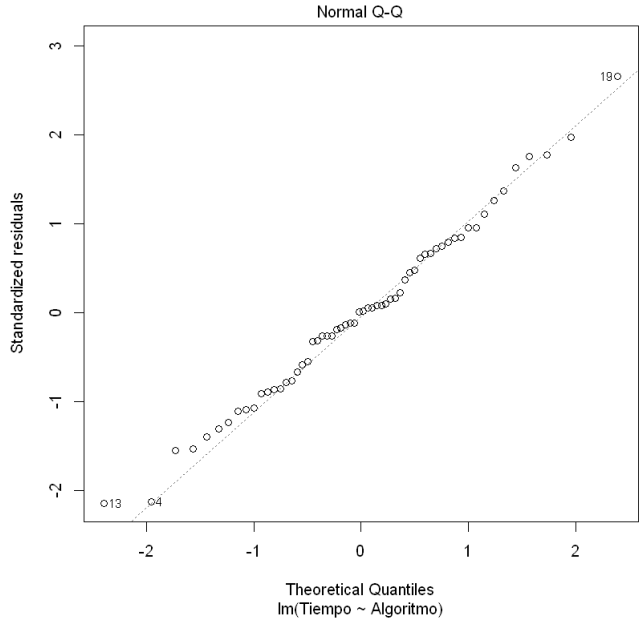

```
Call:
lm(formula = Tiempo ~ Algoritmo, data = Data)

Residuals:
    Min      1Q  Median      3Q     Max
-3370.8 -1211.6    25.1  1065.4  4179.2

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)           12918.8      360.5  35.835  < 2e-16 ***
AlgoritmoAlgoritmo B   -413.2      509.8  -0.810  0.42105
AlgoritmoAlgoritmo C  -1642.7      509.8  -3.222  0.00211 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1612 on 57 degrees of freedom
Multiple R-squared:  0.1647,    Adjusted R-squared:  0.1353
F-statistic: 5.618 on 2 and 57 DF,  p-value: 0.005932
```

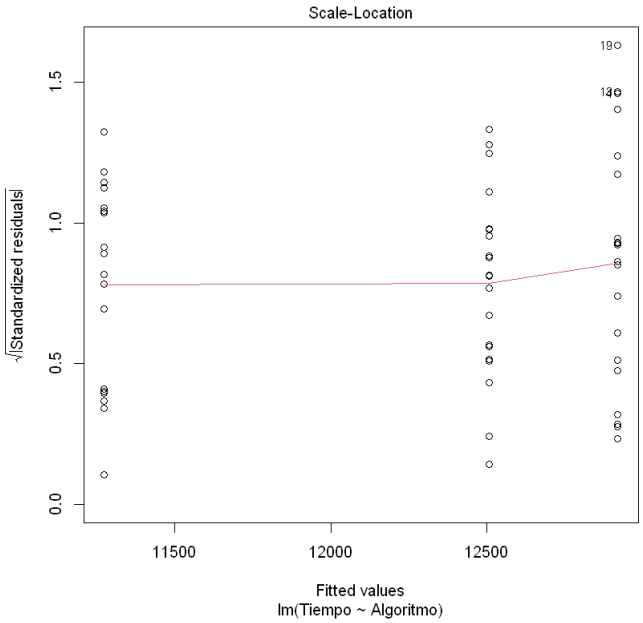



Frequency
0
5
10
15
-4000
-2000
0
2000
4000
x


residuals(model)
-2000
0
2000
4000
11500
12000
12500
fitted(model)


Residuals vs Fitted
Residuals
-4000
-2000
0
2000
4000
11500
12000
12500
Fitted values
lm(Tiempo ~ Algoritmo)





A anova: 2 × 4

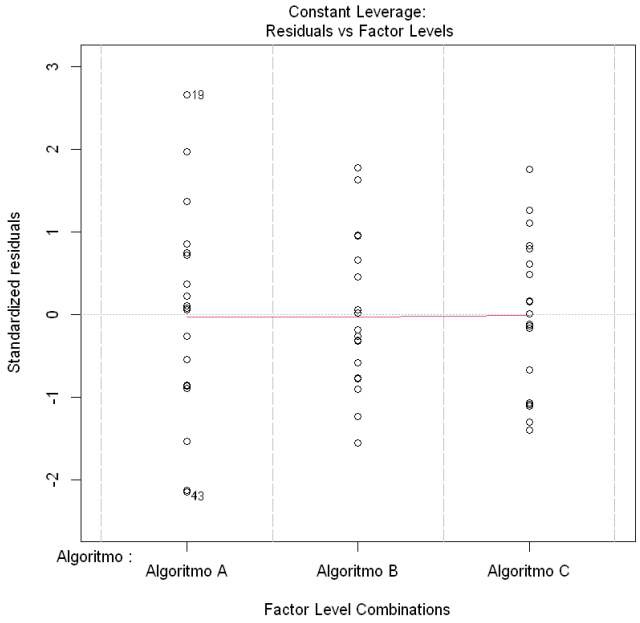
	Sum Sq	Df	F value	Pr(>F)
	<dbl>	<dbl>	<dbl>	<dbl>
Algoritmo	29203870	2	5.617588	0.005931933
Residuals	148161499	57	NA	NA

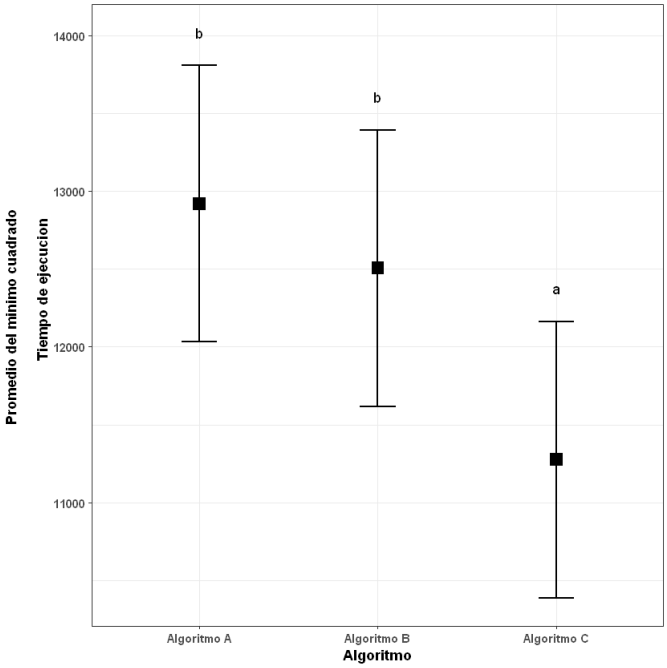
```
contrast                 estimate  SE df t.ratio p.value
Algoritmo A - Algoritmo B      413 510 57   0.810  0.6981
Algoritmo A - Algoritmo C     1643 510 57   3.222  0.0059
Algoritmo B - Algoritmo C     1229 510 57   2.411  0.0494

P value adjustment: tukey method for comparing a family of 3 estimates
```

```
Loading required package: mvtnorm

Loading required package: survival

Loading required package: TH.data

Loading required package: MASS


Attaching package: 'TH.data'


The following object is masked from 'package:MASS':

    geyser


Note: adjust = "tukey" was changed to "sidak"
because "tukey" is only appropriate for one set of pairwise comparisons
```

A summary_emm: 3 × 7

	Algoritmo	lsmean	SE	df	lower.CL	upper.CL	.group
	<fct>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<chr>
3	Algoritmo C	11276.15	360.5083	57	10389.33	12162.97	a
2	Algoritmo B	12505.60	360.5083	57	11618.78	13392.42	b
1	Algoritmo A	12918.80	360.5083	57	12031.98	13805.62	b




Promedio del minimo cuadrado
Tiempo de ejecucion
14000
13000
12000
11000
b
b
a
Algoritmo A
Algoritmo B
Algoritmo C
Algoritmo